

Southern Ute Indian Reservation

General Setting

The Southern Ute Indian Reservation is in southwestern Colorado adjacent to the New Mexico border (Figs. SU-1 and -2). The reservation encompasses an area about 15 miles (24 km) wide by 72 miles (116 km) long; total area is approximately 818,000 acres (331,000 ha). Of the Indian land, 301,867 acres (122,256 ha) are tribally owned and 4,966 acres (2,011 ha) are allotted lands; 277 acres (112 ha) are federally owned (U.S. Department of Commerce, 1974). The rest is either privately owned or National Forest Service Lands. The Tribal land is fairly concentrated in two blocks; one in T 32-33 N, R 1-6 W, and the other in T 32 N, R 8-13 W and T 33 N, R 11 W. Most of the allotted land is along or near Los Pinos River. This “checker-boarding” has had a profound effect on the development of the Southern Ute people. Unlike many tribes where they are isolated from outside influence, the Southern Utes have lived alongside non-Indians since the late 1800’s.

The Tribal headquarters are located 1 mile north of the town of Ignacio (Fig. SU-2). The city of Durango is located just outside the north boundary of the Reservation, 24 miles northwest of Ignacio.

The population of the Tribe is currently 1,135 people. The Tribe is growing rapidly with over half of the population under the age of 25. Approximately 25 percent of the membership lives off the Reservation, mostly in larger metropolitan areas such as Denver, Albuquerque, and Phoenix. There are 300 Tribal members in the local work force. In addition to Tribal Members, there are approximately 30,000 people living in La Plata County.

Topography of the reservation is generally rugged. West of Animas River, the eastern flank of Mesa Verde is cut by numerous small canyons. Eastward the hills become more rounded and timber covered. Elevations range from about 6,000 feet along La Plata River near the southwest corner and along the San Juan River near Arboles, to 8,551 feet at Piedra Peak (sec 24, T33N, R6W). Principal streams on the Reservation are the San Juan, Piedra, Animas, Florida, and La Plata Rivers. The Navajo Reservoir, formed by Navajo Dam in New Mexico, forms a significant body of water on the San Juan River and the lower Piedra River in the eastern part of the reservation (Fig. SU-2); water surface is at an elevation of about 6,100 feet.

Ignacio, with a population of 613 in 1970, is the largest town on the reservation, and site of the Southern Ute Indian Agency. The nearest large town is Durango, Colorado with a population of 10,333. It is about 5 miles north of the reservation (Fig. SU-2). Farmington, New Mexico, with a population of 21,979 (1980), lies to the south about 29 miles from the reservation boundary.

The climate is temperate with an annual average of 16 inches of rainfall. The growing season is about 109 frost free days between May and September.

The Southern Ute Indian Tribe is blessed with an abundance of valuable natural resources. A major source of revenue for the Tribe is the production of oil and natural gas. Recent drilling and production activity has focused on coal-bed methane gas which

occurs throughout the coal seams underlying the Reservation. The coal, estimated to be in excess of 200 million tons of strippable coal, is high quality (10,000 BTUs per lb.) and with low sulfur content.

Leasing of minerals and development agreements on the Southern Ute Indian Reservation are designed in accordance with the Indian Mineral Development Act of 1982, and the rules and regulations contained in 25 CFR, Part 225 (published in the Federal Register, March 30, 1994). The Tribe no longer performs lease agreements under the old 1938 Act (since 1977).

The 1982 Act provides increased flexibility to the Tribe and developer to tailor their agreements to the specific needs of each party. It also allows the parties to draft agreements based on state-of-the-art oil and gas agreements used in industry rather than standard Bureau of Indian Affairs forms. The Act also contains sections which set forth the responsibilities of BLM and MMS offices. The regulations contain a 21 point check list for matters which should be considered, and if appropriate, included in any mineral agreement.

Inquiries regarding new leasing should be directed to Robert Santistevan, Director of Energy Resources, Red Willow Production Company at:

Red Willow Production CO
Production Operating/Acquisition
P.O. Box 737
Tribal Annex bldg., 2nd Fl
Ignacio, CO 81137

Tel: (970) 563-0140
Fax: (970) 563-0398

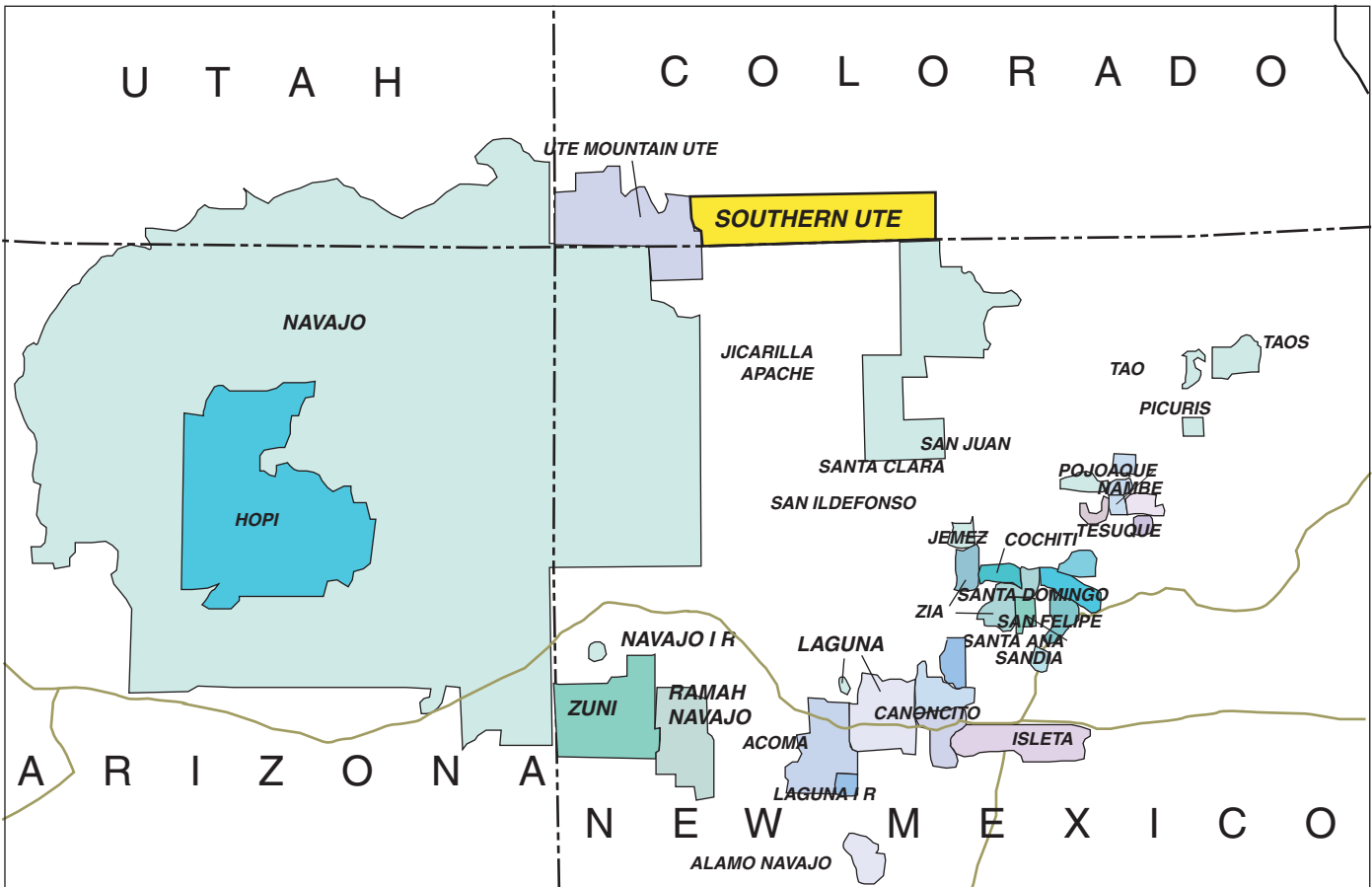


Figure SU-1. Location of Southern Ute Indian Reservation with respect to other Indian Reservations (modified after Indian Land Areas, 1993).

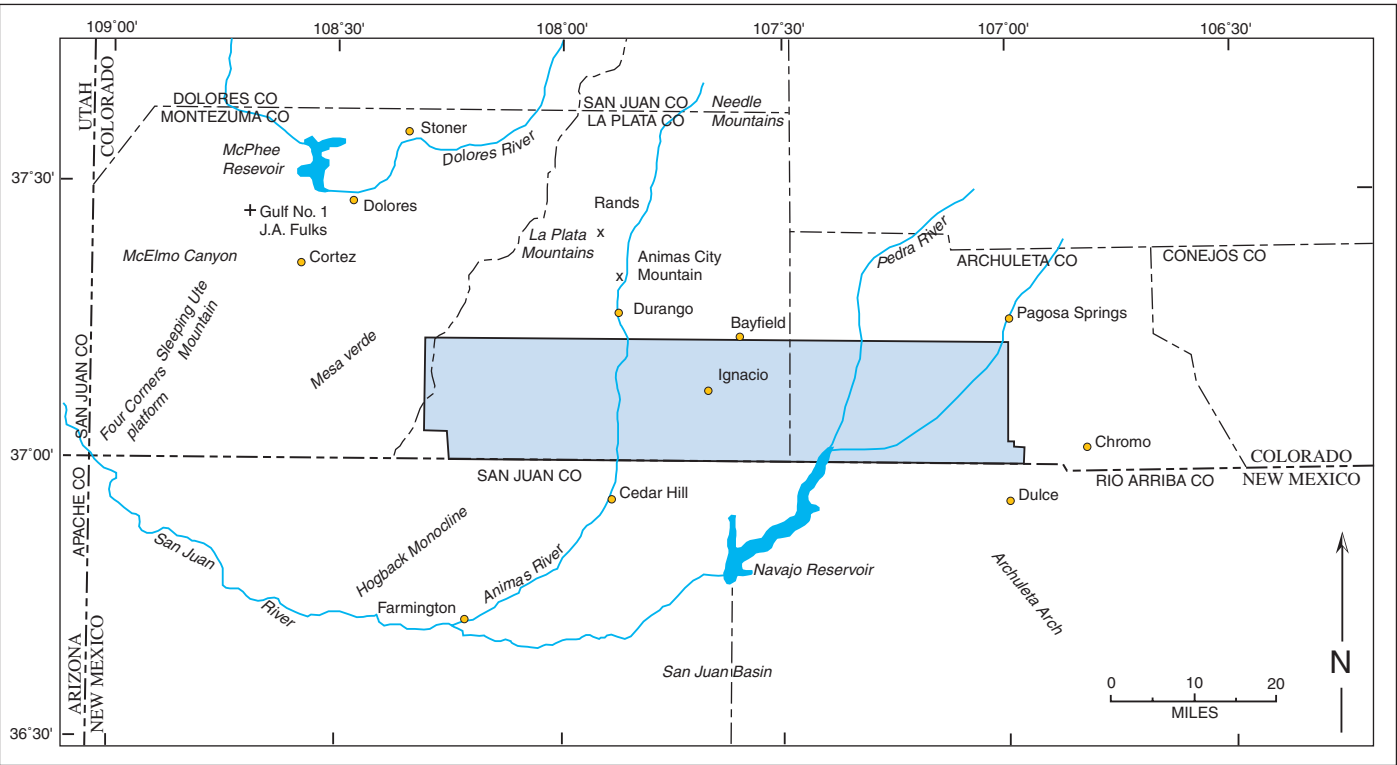


Figure SU-2. Index map showing the Southern Ute Indian Reservation and adjacent areas (modified after Condon, 1992).

Geology

The Southern Ute Indian Reservation is on the northern margin of the San Juan Basin, a large circular structural depression whose center is some 50 miles southeast of Durango (Fig. SU-3). The sedimentary layers that fill the San Juan Basin dip gently toward its center. Their outcrop pattern around the basin is a series of concentric bands, with the younger rocks toward the center and the older rocks toward the margin. Nearly all the rocks exposed at the surface on the Reservation are sedimentary rocks of Late Cretaceous or Early Tertiary age (Fig. SU-4).

Geologic Structure

The Southern Ute Indian Reservation is located in the northern part of the structural and sedimentary San Juan Basin. The present structure was largely shaped by Laramide (Late Cretaceous through Eocene) and later tectonic activity. The area was also on the edge of the older Paleozoic Paradox Basin during deposition of the sediments of the Pennsylvanian Hermosa Group (Condon, S.M., 1992)

Figures SU-3, -4, and -5 show various structural elements in southwestern Colorado and northwestern New Mexico. The structure contours in Figures SU-4 and -5 show effects of Laramide deformation. The San Juan Basin is flanked on the west by the Hogback Monocline and on the east by the Archuleta Arch. The monocline rim extends unbroken around the northern rim of the basin. Superimposed on these major structures are several smaller ones: the Barker anticline and Red Horse syncline in the southwest corner of the Reservation, the Ignacio anticline and H-D Hills syncline in the central part, and several northwest-trending anticlines, synclines and faults at the east end.

A structural bench, the Four Corners Platform, lies between the San Juan Basin and the Blanding Basin (Fig. SU-3). Upper Cretaceous to Tertiary laccolith intrusions of Ute dome and the La Plata dome are evident (Fig. SU-3). The northern rim of the San Juan Basin is defined by the uplift of the San Juan Dome. The Chama basin and the San Juan sag are low structural features on the east and northeast sides, respectively, of the Archuleta arc (Fig. SU-5).

The principal structures of economic significance are the Barker anticline, which produces gas from the Dakota and Hermosa Groups, and the Ignacio anticline, which produces gas mainly from the Mesaverde and subordinately from several other formations from the Fruitland down to the Morrison (Fig. SU-4).

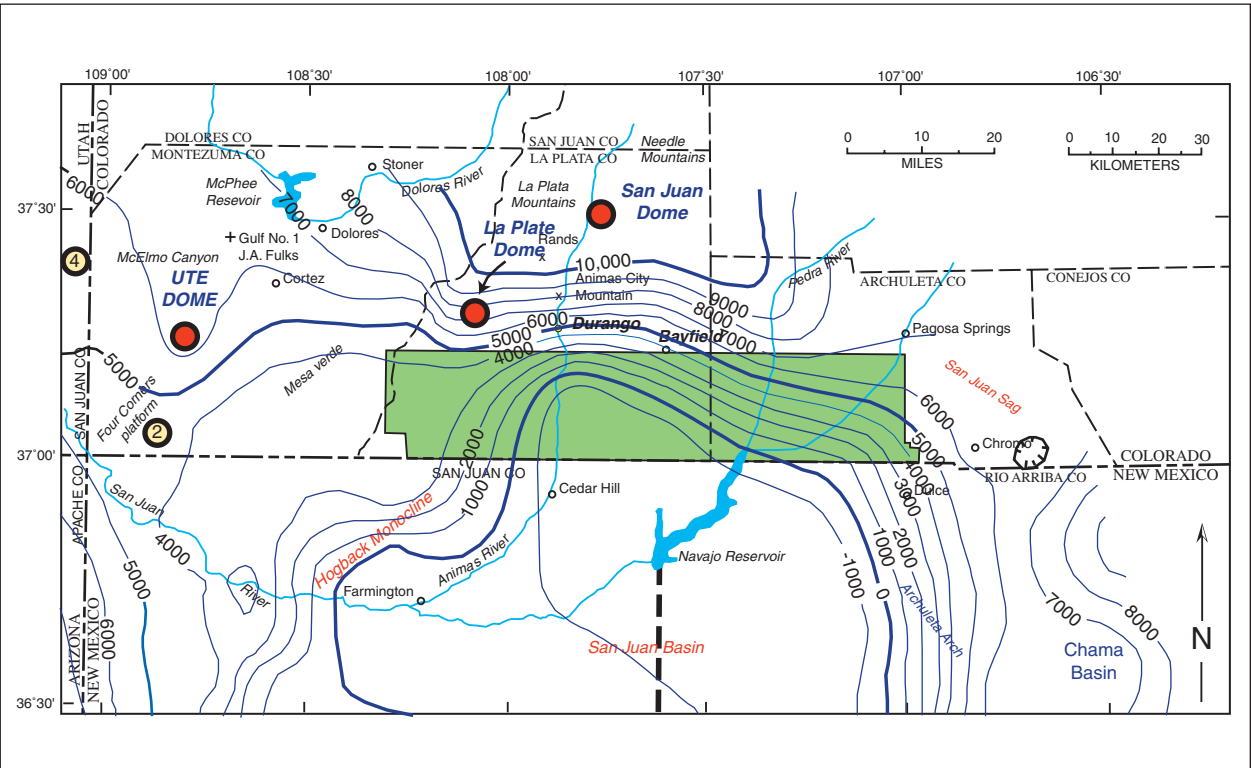
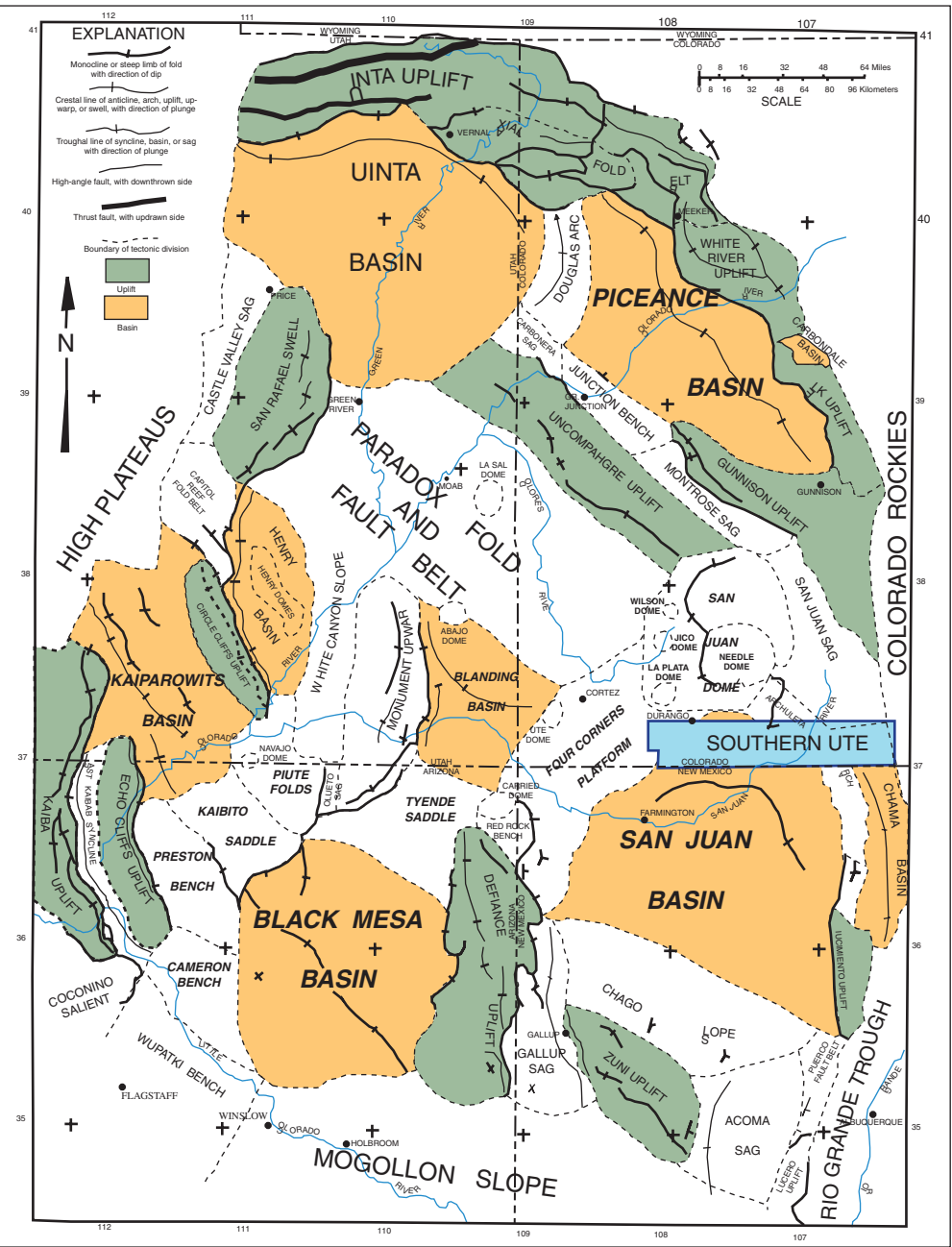


Figure SU-5. Structure Contour map under and adjacent to the Southern Ute Indian Reservation. Structure contours are drawn on the top of the Jurassic with a contour interval of 1000 feet. Major structural features are labeled (modified after Condon, 1992).

Figure SU-3. Tectonic divisions of the Colorado Plateau (modified after Kelley, 1958).

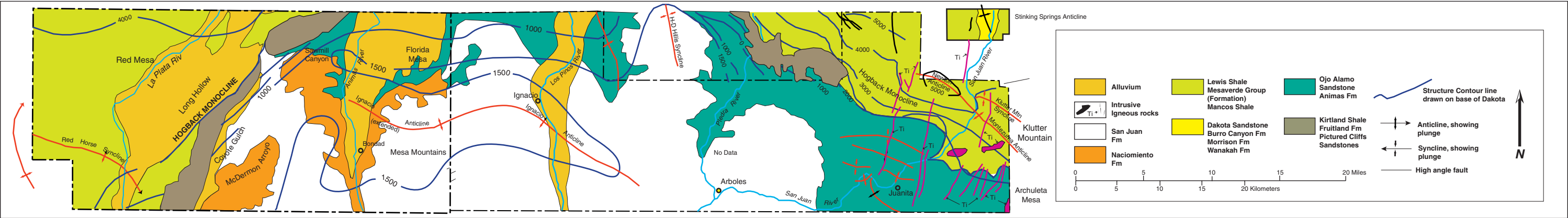


Figure SU-4. Generalized geologic and structure map of the Southern Ute Indian Reservation. Structure lines are drawn on the base of the Dakota Sandstone (modified after Anderson, 1995).

Stratigraphic Overview

The following is a brief description of the stratigraphy under the Southern Ute Indian Reservation. The formations of oil and gas significance will be discussed in more detail in the “Play Summary Overview”. Please refer to Figures SU-4, 5, 6, and 7.

Older Paleozoic Systems

The oldest formation in the subsurface of the Southern Ute Indian Reservation is the Upper Cambrian Ignacio Quartzite which unconformably overlies Precambrian metamorphic and igneous rocks (Fig. SU-6). The Ignacio is as thick as 150 feet in the northwest part of the Reservation and thins to about 30 feet in the Piedra River canyon about 20 miles west of Pagosa Springs. It consists mainly of white, reddish-brown, and light-brown conglomerate; feldspathic and quartzoes sandstone; purple to green, burrowed, micaceous mudstone and siltstone; and minor dolomite. The sandstone is very coarse to fine grained. Bedding is thin to thick in tabular layers with small to medium scale crossbeds. The lower Ignacio Quartzite was deposited subaerially in streams and on alluvial fans. The upper Ingacio Quartzite is a shallow-shelf assemblage of strata that was deposited by the eastward transgressing sea. There is no production of hydrocarbons or any other economic resource from the Ignacio in the vicinity of the Reservation.

The Cambrian-Devonian McCracken Sandstone Member and Upper Member of the Elbert Formation unconformably overly the Ignacio Quartzite and basement rocks (Fig. SU-6). The McCracken Sandstone Member ranges from 0 -140 feet thick on the Reservation. The McCracken consists of gray to brown sandstone, brown and gray dolomite, and greenish-gray shale. The dominant lithology is very fine to coarse grained sandstone. It is composed of shallow marine, nearshore sediments that were deposited during a eustatic sea-level rise in the Late Devonian. The Upper Member of the Elbert Formation ranges from 150 to 250 feet thick on the Reservation. It consists of poorly exposed, thinly bedded, brownish-gray, sandy dolomite and sandstone; green to red shale; and minor anhydrite. The sediments were deposited in a shallow, tidal-flat environment.

The Devonian Ouray Limestone conformably overlies the Elbert Formation (Fig. SU-6). The Ouray is 100 feet thick in the western part of the Reservation and pinches out in the eastern part of the Reservation. It is composed of dark-brown to light-gray, dense, argillaceous limestone with local green clay partings.

The Lower Mississippian Leadville Limestone unconformably overlies the Ouray Limestone. The Leadville ranges in thickness from nearly zero on the east side of the Reservation to about 250 feet on the west side. The Leadville is composed of yellowish-brown and light to dark-gray finely to coarsely crystalline, fossiliferous dolomite and limestone. The Leadville formed during two transgressive episodes in the Mississippian. The sediments were deposited under a variety of depositional environments ranging from shallow water tidal flats to low-energy stable-shelf conditions to high-energy shoals. Another unconformity separates the Leadville Limestone

from the Lower Pennsylvanian Molas Formation.

Pennsylvanian System

The Molas Formation averages 60 feet thick on the Reservation. The Molas Formation is composed of three members. They are the Coabank Hill Member, the Middle Member, and the Upper Member. They range from shale to conglomerate with some fossiliferous limestone.

The Hermosa Group conformably overlies the Molas Formation. It ranges in thickness from 400 feet on the southeast side to thicker than 2,000 feet. The Hermosa Group consists of (from oldest to youngest) the Pinkerton Trail Formation, the salt-bearing Paradox Formation and the Honaker Trail Formation. The Paradox Formation is composed of four main cycles of Desmoinian deposition. The cycles are the Ismay, Desert Creek, Akah, and Barker Creek Stages. These are cyclic deposits of dolomite, limestone, and black, carbonaceous shale. Porosity is 10% and more, which has made these cycles important as an oil and gas reservoir.

Pennsylvanian and Permian Systems

The Rico Formation averages about 200 feet thick on the Reservation. It is composed of conglomeratic sandstone and arkose interbedded with greenish-, reddish-, and brownish- gray shale and sandy fossiliferous limestone. The Rico Formation represents the transition between the Cutler Group and the Hermosa Group.

Lower Permian System

The Cutler Group ranges from 1,200 to 1,700 feet thick on the Reservation. It is mostly nonmarine red shale, siltstone, mudstone, sandstone, and conglomerate. It is composed of (from oldest to youngest) the Halgaito Formation, Ceder Mesa Formation, Organ Rock Shale, and the De Chelley Sandstone (Fig. SU-6).

Triassic System

The Dolores Formation ranges in thickness from about 900-1,200 feet on the west side of the Reservation. It is composed mostly of interbedded red to purplish-red, very fine to coarse grained sandstone, conglomerate, siltstone, and mudstone. The Dolores is interpreted to be fluvial-channel, flood plain, lacustrine, and eolian sand-sheet deposits.

Jurassic System

The Entrada Sandstone unconformably overlies the Dolores Formation and is composed of light-gray, cross-bedded sandstone. Maximum thickness is about 250 feet. The overlying Morrison Formation is composed of two members, the Salt Wash Member which is mostly sandstone with interbedded claystone and mudstone, and the overlying Brushy Basin Member which is mostly varicolored claystone and mudstone. Maximum thickness of the Morrison Formation is about 800 feet.

Cretaceous System

The Early Cretaceous Burro Canyon Formation disconformably overlies the Morrison Formation. Like the Jurassic rocks, the Burro Canyon is exposed only at the northeast corner of the reservation. It is about 1000 feet thick in the Reservation and consists of lenticular

conglomerate and conglomeratic fluvial-channel sandstone bodies.

The Late Cretaceous (Cenomanian) Dakota Sandstone lies either disconformably over the Burrow Canyon Formation or unconformably over the Morrison Formation Fig. SU-6). It is exposed only in the valley of the San Juan River in the northeast corner of the Reservation, but it underlies the entire Reservation in the subsurface. It was deposited in response to the initial transgression of the upper Cretaceous epeiric sea. The Dakota formed in a variety of environments and consists of a basal alluvial unit that is overlain by deltaic, marginal-marine, and marine rocks in different parts of the region. Its thickness on the Reservation is not known, but nearby to the north it is 177-270 feet thick.

The Late Cretaceous Mancos Shale conformably overlies the Dakota Sandstone and intertongues with the overlying Point Lookout Sandstone. It underlies the entire Reservation and outcrops in the northeast corner. It is mostly a dark gray marine shale and its maximum subsurface thickness on the Reservation is about 2,400 feet. The lower part, about 500 feet thick, contains thin limy shale and limestone in the lower 150 feet. The upper part, about 1,900 feet thick, has sandy limestone and clayey sandstone at its base and contains some limestone or limy beds in its lower 600 feet; it grades upward into fine-grained shaly sandstone.

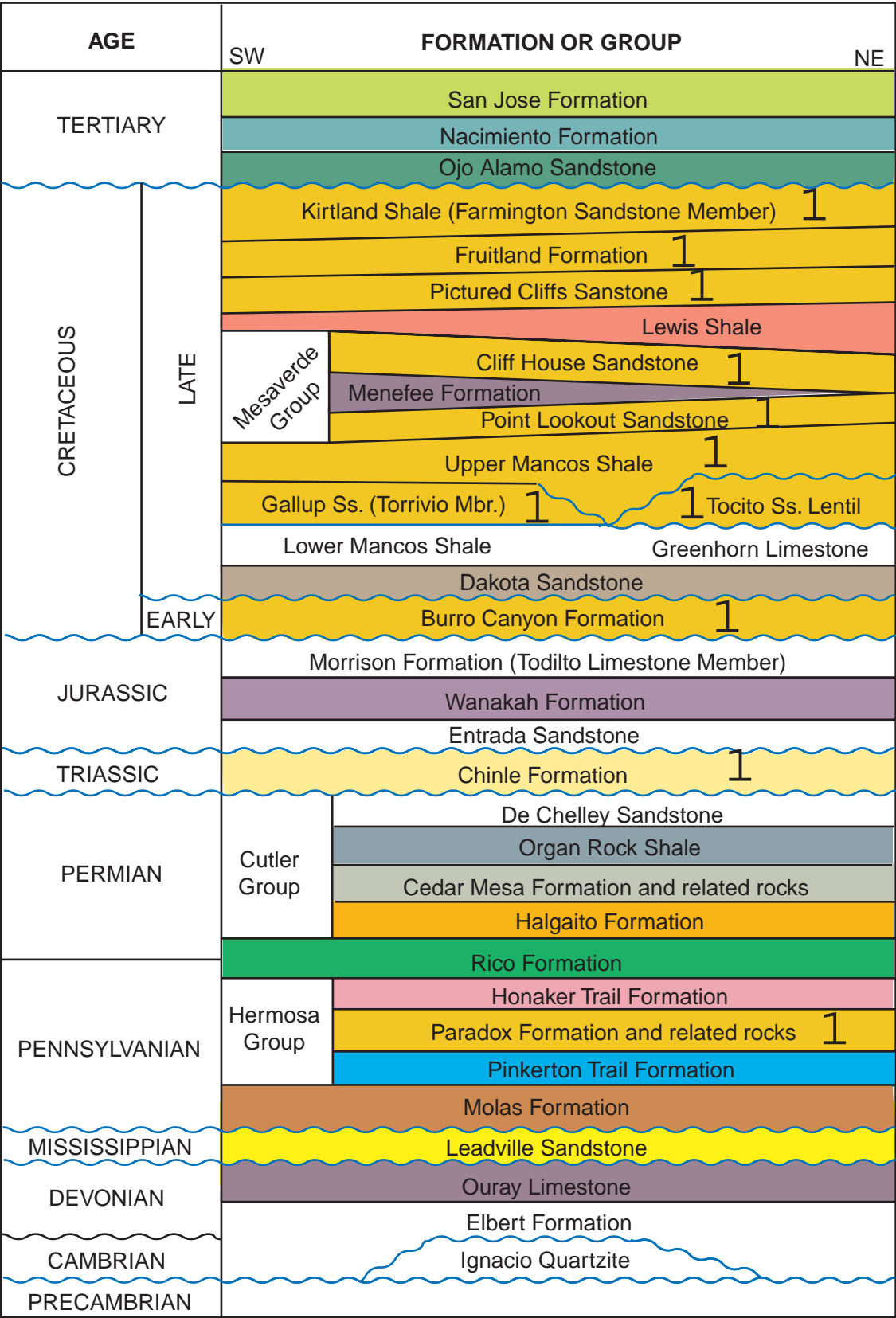


Figure SU-6. Geochronologic chart for the San Juan Basin. Yellow units are productive in the Southern Ute Indian Reservation (modified after Gautier et al., 1996).

Overlying the Mancos Shale is the series of interbedded sandstones of the Late Cretaceous Mesaverde Group. It is composed of the Point Lookout Sandstone, the Menefee Formation, and the Cliff House Sandstone (Fig. SU-6). The Mesaverde Group forms several small mesas in the northeastern part of the reservation. The outcrop continues to the west in an arc north of the reservation, and reenters it on the west side, where the Cliff House Sandstone lies at the surface of nearly all the reservation west of the La Plata River.

The Point Lookout Sandstone, at the base of the Mesaverde Group, conformably overlies and is transitional with the Mancos Shale. In the area of the Reservation, the Point Lookout Sandstone is divided into a lower sandstone and shale member and an upper massive sandstone member. The sandstone and shale member is about 80-125 feet thick and is composed of interbedded yellowish gray, fine-grained, cross-laminated sandstone and sandy dark-olive-gray, fossiliferous shale; the amount of sandstone in the member increases upward toward the overlying massive sandstone member. The upper massive sandstone member is about 200-250 feet thick and is composed of thick to massive beds of light-gray to yellowish-gray, crossbedded, fine- to medium-grained sandstone. The contact with the overlying Menefee Formation is conformable and sharp in most places.

The Menefee Formation consists of a series of interbedded lenses of sandstone, siltstone, shale, and coal. Irregular bedding and rapid lateral changes of lithology are characteristic of the formation. The sandstones and siltstones are various shades of light gray and yellowish gray and range in grain size from coarse sand to very fine silt. The shales are mostly shades of dark gray or brown. The coal beds are lenticular and in many places grade both horizontally and vertically into carbonaceous clay shale and carbonaceous shaly sandstone. Thin coal beds occur throughout the formation, but most coal beds more than 1.2 feet thick are in the lowermost 50-60 feet of the formation, and a few are immediately below the top. The Menefee thins to the northeast and pinches out in the eastern part of the Reservation.

The Cliff House Sandstone is a sandstone and shale sequence in the vicinity of the Reservation. The unit consists of sandstone, siltstone, and shale in varying proportions, with sandstone becoming thicker toward the southwest. On Weber Mountain, a few miles northwest of the Reservation, the Cliff House consists of an upper sandstone unit 65 feet thick, a middle shaly unit 210 feet thick, and a lower sandy unit 70 feet thick. The shaly unit wedges out within a few miles southward; as a result, the subsurface Cliff House Sandstone at and beneath the surface in the western part of the Reservation may be presumed to be predominantly sandstone. The total thickness is about 400 feet, but some of this has been eroded where the formation is at the surface. The Cliff House Sandstone interfingers laterally and vertically with the overlying marine Lewis Shale and with the underlying deltaic deposits of the upper member of the Menefee Formation.

The Late Cretaceous Lewis Shale is a marine shale that was deposited in late Campanian time (Figs. SU-6, SU-7). It consists primarily of light-to dark-gray and black shale with interbeds of fine-

grained sandstone, limestone, calcareous concretions, and bentonite. It crops out on the west side of the Reservation in a northeast-trending band marked by Long Hollow, and on the east side in a wide sinuous zone that trends northwest from Archuleta Mesa. Thickness of the Lewis ranges from 1,440 to 1,825 feet on the west side of the Reservation, and increases eastward to about 2,400 feet on the east side.

The Late Cretaceous Pictured Cliffs Sandstone was deposited during the final regression of the epeiric Cretaceous sea during Campanian time (Figs SU-6, SU-7). It forms a hogback from Cinder Buttes to Bridge Timber Mountain on the west side of the Reservation, and on the east side forms the lower part of the steep northeast-facing slopes that extend from Archuleta Mesa to the Piedra River. In its western exposures the formation is from about 215 feet to 285 feet thick. The Pictured Cliffs is divided into an upper part that consists of one or more massive sandstone beds interbedded with some thin shale beds and a lower transitional zone composed of relatively thin intercalations of sandstone and shale. The lower transitional zone consists of thin, grayish-orange and light-olive-gray, very fine grained sandstone, interbedded with subordinate amounts of gray shale and siltstone. The upper part is composed primarily of dark-yellowish-orange and light-gray, medium- to thick-bedded, ledge-forming sandstone. The formation thins eastward to 90 feet on Klutier Mountain just east of the Reservation, but the general lithology remains the same. The contact with the overlying Fruitland Formation is conformable, with local intertonguing.

The Late Cretaceous Fruitland Formation is a sequence of interbedded and locally carbonaceous sandstones, siltstones, shales, coal and locally in the lower part of the formation, thin limestone beds. The lithology of the formation is characterized by lateral discontinuity, most individual beds pinching out within a few hundreds of feet. The coal beds, are more continuous and may be traced for several miles. Although coal beds occur throughout the formation, the thickest and most persistent beds are in its lower part. The limestone beds are found only in the lowermost part of the formation, sandstone is usually more abundant in the lower part than in the upper part, and siltstone and shale predominate the upper part. The formation ranges from about 300 to 500 feet thick on the west side of the Reservation, but thins eastward to about 300 feet in its outcrop area on the east side. The contact with the Kirtland is gradational, and most geologists place the top at the highest bed of coal or carbonaceous shale.

The Late Cretaceous Kirtland Shale is divided into a lower shale member, a middle sandstone unit called the Farmington Sandstone Member, and an upper shale member. In the western part of the Reservation, the lower shale member consists of olive- to medium-gray sandy shale that commonly contains lenses of nonresistant olive-gray, fine grained sandstone. The lower member also contains thin lenses of carbonaceous shale and abundant amounts of silicified wood at various horizons. The Farmington Member on the western part of the Reservation is a sequence of resistant sandstones that are separated by beds of shale. The upper shale member on the western part of the Reservation consists of shale and interbedded lenses of nonresistant, friable sandstone. The age of the Kirtland is Late Cretaceous (Campanian to Maastrichtian). The contact between the Kirt-

land Shale and the Animas Formation, which overlies it on most of the Reservation, is transitional and arbitrary.

Cretaceous and Tertiary Systems

Immediately overlying the Kirtland shale over most of the Reservation is the Animas Formation. It ranges in age from Late Cretaceous-Early Paleocene but in the southeastern part of the Reservation it is only Paleocene. The Animas Formation crops out in a band of variable width forming an east-west arc across the Reservation. The Ani-

mas is characterized by conglomerate beds, containing boulders and pebbles of andesite in a tuffaceous matrix. Interbedded with variegated shale and sandstone. On the west side of the Reservation the McDermott Member (Late Cretaceous) has a maximum thickness of 290 feet, which thins to the south and east. The upper member (Paleocene) has a maximum of 2,670 feet near the La Plata-Archuleta County line (north of the Reservation), and thins to 1,840 feet on Cat Creek.

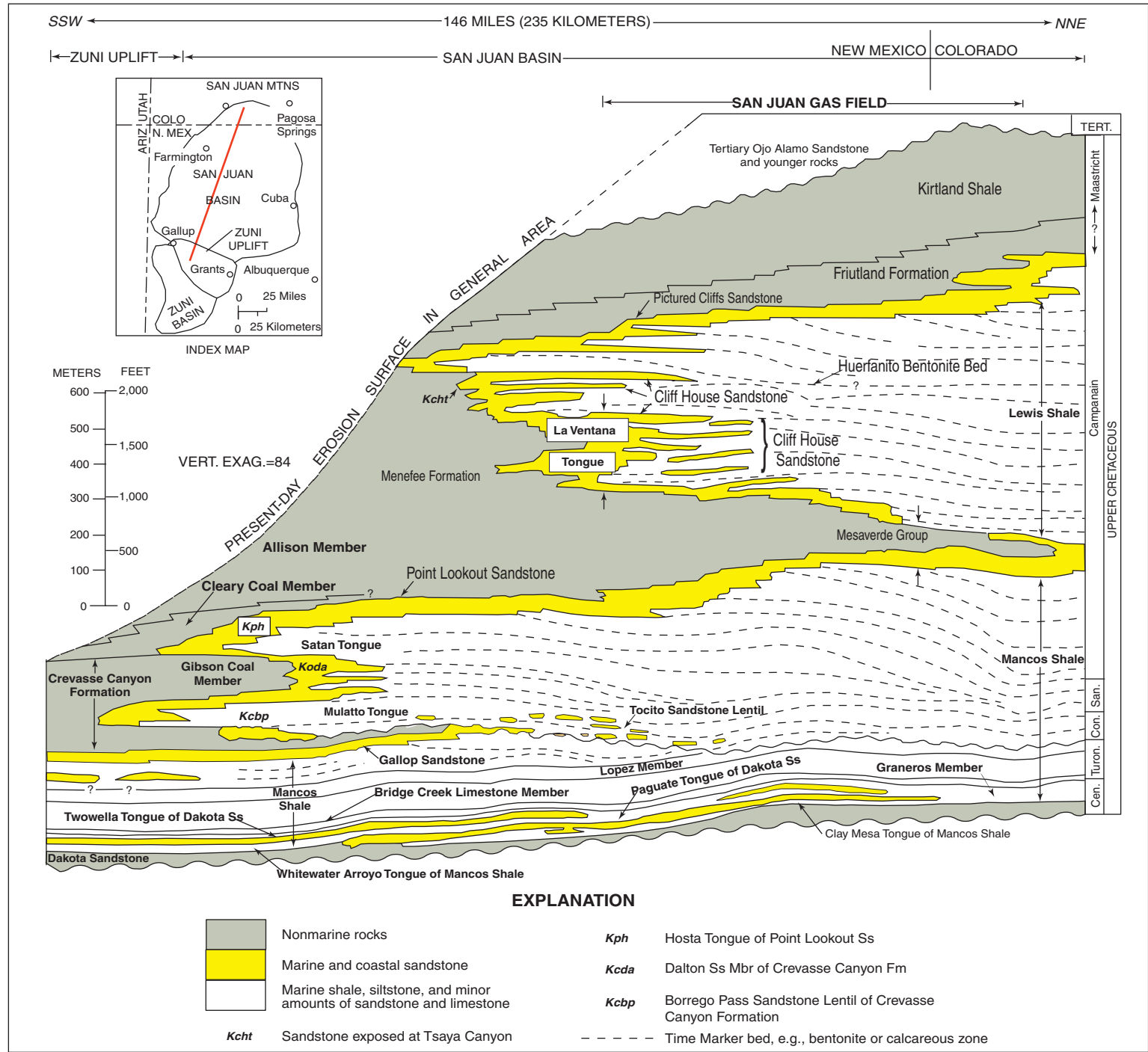


Figure SU-7. Stratigraphic cross section showing upper Cretaceous rocks across the San Juan Basin, New Mexico and Colorado (modified after Nummedal and Molenaar, 1995).

Production Overview

Oil and gas production in the San Juan Basin was described in the “1995 National Assessment of United States Oil and Gas Resources” (Gautier, D.L., et al., 1996). All plays discussed in the “Play Summary Overview” are defined by that publication. The “Play Summary Overview” combines the research from that publication along with other recent publications in the Southern Ute Indian Reservation. The following is a summary of the San Juan Basin Province as described in “1995 National Assessment of United States Oil and Gas Resources”

San Juan Basin Province

The San Juan Basin province incorporates much of the area from latitude 35° to 38° N. and from longitude 106° to 109° W. and comprises all or parts of four counties in northwest New Mexico and six counties in southwestern Colorado (Huffman, 1996). It covers an area of about 22,000 sq mi (Fig. SU-8).

Almost all hydrocarbon production and available subsurface data are restricted to the topographic San Juan Basin. Also included in the province, but separated from the structural and topographic San Juan Basin by the Hogback monocline and Archuleta arch, respectively, are the San Juan Dome and Chama Basin, which contain sedimentary sequences similar to those of the San Juan Basin. In much of the San Juan Dome area the sedimentary section is covered by variable thicknesses of volcanic rocks surrounding numerous caldera

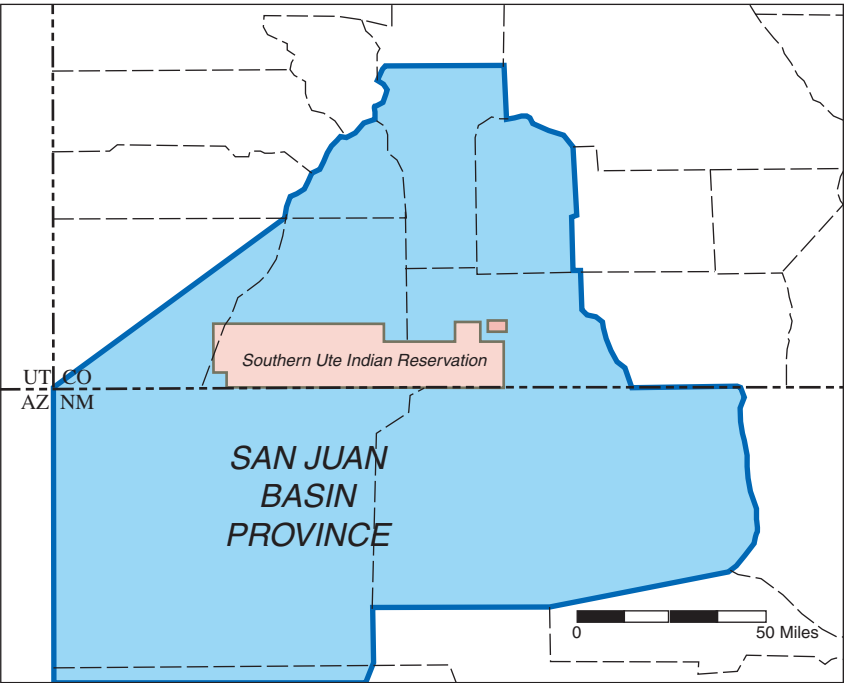


Figure SU-8. Location of U.S.G.S. San Juan Basin Province with respect to the Southern Ute Indian Reservation (modified after Gautier et al., 1996).

structures. The stratigraphic section of the San Juan Basin attains a maximum thickness of approximately 15,000 ft in the northeast part of the structural basin where the Upper Devonian Elbert Formation lies on Precambrian basement. Elsewhere in the province Cambrian, Mississippian, Pennsylvanian, or Permian rocks may overlie the Precambrian.

Plays were defined primarily on the basis of stratigraphy because of the strong stratigraphic controls on the occurrence of hydrocarbons throughout the province. In general, the plays correspond to lithostratigraphic units containing good quality reservoir rocks and with connections to source beds. In the central part of the basin, porosity, permeability, stratigraphy, and subsurface hydrodynamics control almost all production, whereas around the flanks, structure and stratigraphy are key trapping factors.

Although most Pennsylvanian-age oil and gas is on structures around the northwestern margin, hydrocarbons commonly accumulate only in highly porous limestone buildups. Jurassic oil on the southern margin of the basin is stratigraphically trapped in eolian strata at the top of the Entrada Sandstone. Almost all oil and gas in Upper Cretaceous sandstones of the central basin is produced from stratigraphic traps. Around the flanks of the basin, some of the same Cretaceous units produce oil on many of the structures.

Seven conventional plays were defined and individually assessed in the province; Porous Carbonate Buildup (2201), Marginal Clastics (2203), Entrada (2204), Basin Margin Dakota Oil (2206), Toci-to/Gallup Sandstone Oil (2207), Basin Margin Mesaverde Oil (2210), and Fruitland-Kirtland Fluvial Sandstone Gas (2212). The Porous Carbonate Buildup Play (2201) is assessed as part of play 2102 in the Paradox Basin; similarly, Permian–Pennsylvanian Marginal Clastics Gas Play (2203) is assessed as part of play 2104 in the Paradox Basin, so is not discussed further here.

Eight unconventional plays were also assessed--five continuous-type plays and three coalbed gas plays. Continuous-type plays are Fractured Interbed (2202), Dakota Central Basin Gas (2205), Mancos Fractured Shale (2208), Central Basin Mesaverde Gas (2209), and Pictured Cliffs Gas (2211). Also present is the continuous-type Fractured Interbed Play (2103) which is described and assessed in Paradox Basin Province (021). Coal-bed gas plays are San Juan Basin–Overpressured (2250), San Juan Basin–Underpressured Discharge (2252), and San Juan Basin–Underpressured (2253). The plays of interest to the Southern Ute Indian Reservation are described in the “Play Summary Overview”.

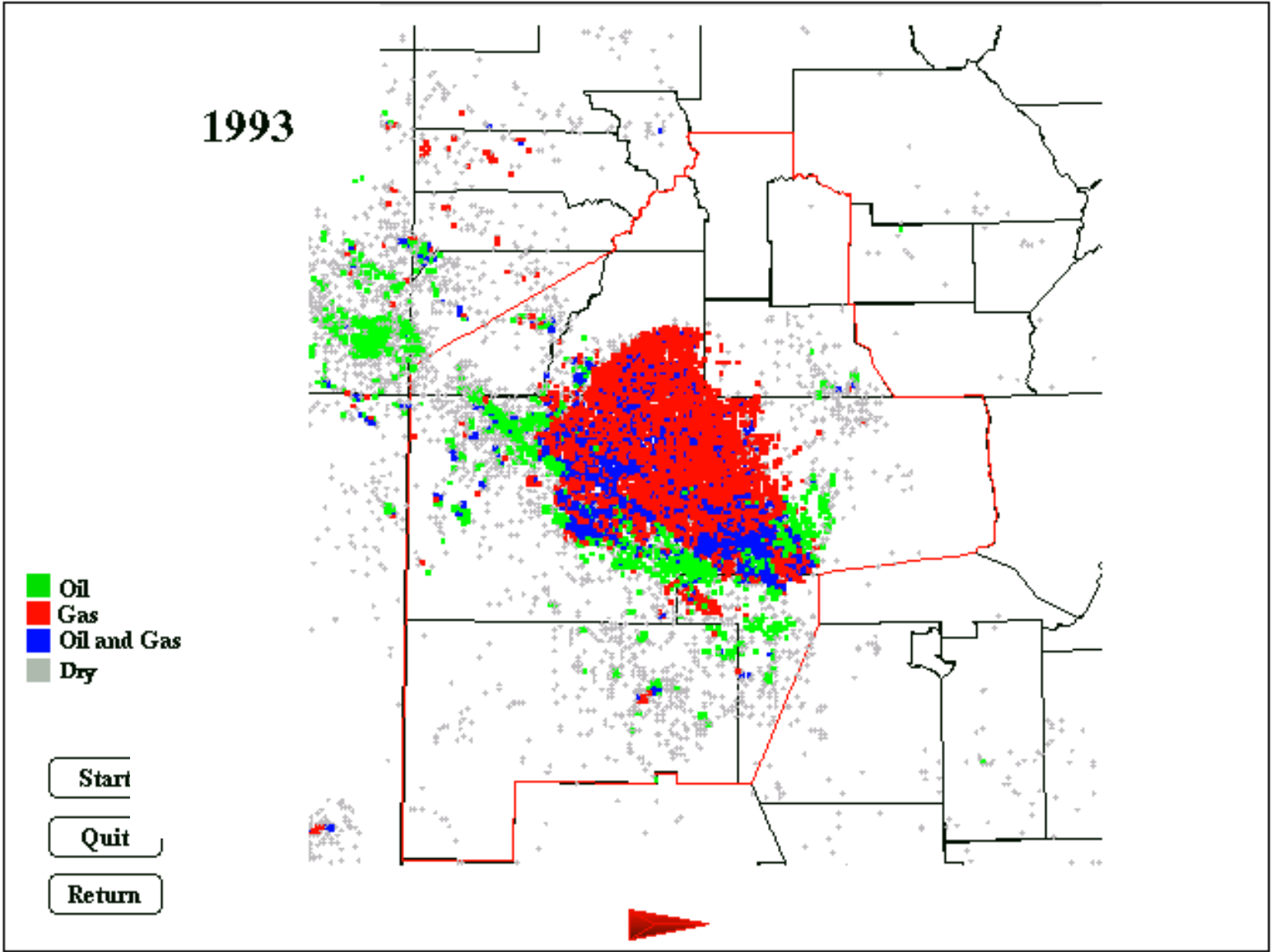


Figure SU-9. Locations of oil and gas production wells, cumulative through 1993 (modified after Gautier et al., 1996).